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DETAIL JAPANESE

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PATENT ABSTRACTS OF JAPAN

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(21)Application number : 10-077318 (71)Applicant : CANON INC

(22)Date of filing : 25.03.1998 (72)Inventor : YAMAMOTO MASAKUNI

(54) METHOD FOR ANNEALING INFORMATION RECORDING MEDIUM AND OPTICAL INFORMATION RECORDING/REPRODUCING DEVICE USING THE METHOD

(57)Abstract:

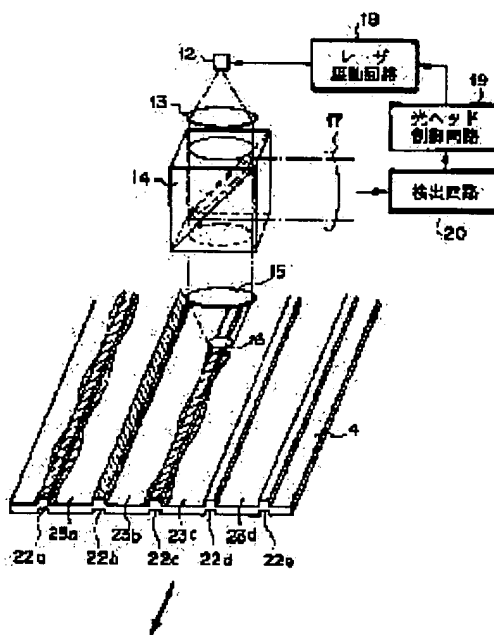
PROBLEM TO BE SOLVED:

To provide an information recording medium annealing method capable of significantly improving recording density without losing recording capacity and an optical information

recording/reproducing device using the annealing method.
SOLUTION: Annealing processing 15 executed by scanning a gap between two information tracks on a magneto-optical disk 4 with an optical spot 16 of high

temperature, and annealing width is changed by modulating the optical intensity

of the optical spot 16 applied to the gap between the information tracks to scan it in accordance with prescribed information, so that the prescribed information in the gap between the information tracks is recorded. The prescribed information is a track number, a sector number, or a synchronizing clock pit.



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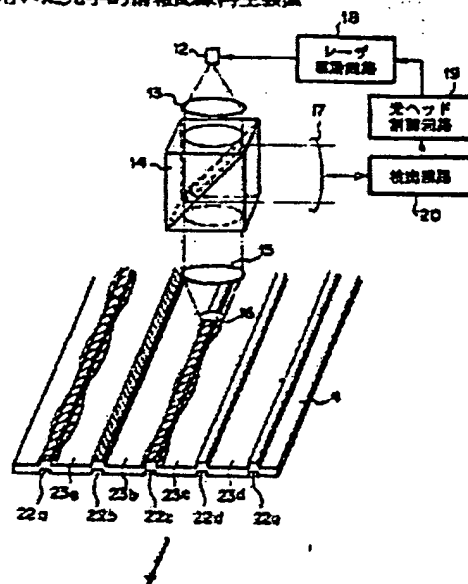
(74) 代理人 弁理士 山下 穰平

(54) 【発明の名称】 情報記録媒体のアニール方法及びそれを用いた光学的情報記録再生装置

(57) 【要約】

【課題】 磁壁移動再生の場合、録密度はサブミクロンと高く、プリピットによる情報の記録では、磁壁移動再生の録密度に比べ著しく低い。

【解決手段】 光磁気ディスク4の情報トラック面に高熱の光スポット15を走査することによりアニール処理を行い、且つ情報トラック面に走査する光スポットの光強度を所定の情報に応じて変調し、アニールする値を変化させることによって情報トラック面に所定情報を記録する。



ができる。図6の例では偏光ビーム スプリッタ46が検光子の役目をしていて、分離した一方の光束に対し、P軸から+45度、他方の光束に対し、P軸から-45度の方向の検光子となる。つまり、光検出器47と48で得られる信号成分は逆相となるので、個々の信号を差動検出することで、ノイズが軽減された再生信号を得ることができる。

【0006】最近では、この光磁気媒体の記録密度を高める要求が高まっている。一般に、光磁気媒体等の光ディスクの記録密度は、再生光学系のレーザ波長及び対物レンズのNA（開口数）に依存する。即ち、再生光学系のレーザ波長 λ と対物レンズのNAが決まると光スポットの径が決まるため、再生可能な磁区の大きさは $\lambda/2NA$ 程度が限界となってしまう。従って、従来の光ディスクでは高密度化を実現するために、再生光学系のレーザ波長を短くするが、あるいは対物レンズのNAを大きくする必要があった。しかしながら、レーザ波長や対物レンズのNAの改善にも限界があるため、記録媒体の構成や読み取り方法を工夫し、記録密度を改善する技術が開発されている。

【0007】例えば、本願出題人は、特開平6-290496号公報で複数の磁性層を積層してなる光磁気媒体上のトラックに対して光スポットで走査することにより、第1の磁性層に垂直磁化として記録されている磁区（マーク）を、交換結合力を調整するための第2の磁性層を挟んで配置された第3の磁性層に転写し、その第3の磁性層に転写した磁区の磁壁を移動させることにより、第1の磁性層に記録されている磁区よりも大きくしてから再生信号を得る磁壁移動再生方式を提案している。

【0008】図8～図10を用いてこの磁壁移動再生方式を説明する。図8は磁壁移動再生方法の原理を説明する図である。(a)は磁性層の構成を示す断面図、

(b)は光スポットが入射する側から見た平面図である。図中54は光磁気媒体である光磁気ディスクであり、3層の磁性層からなっている。まず、55は第1の磁性層であり、磁区として情報を記録する記録層である（以下、記録層とする）。56は第2の磁性層で、第1の磁性層55と第3の磁性層57との間の交換結合力を調整するための調整層である（以下、調整層とする）。第3の磁性層57は記録層55に記録されている磁区を、調整層56の働きと光スポットによる熱分布とを利用して転写し、更に転写した磁区の磁壁を移動させることにより、記録層55に記録されている磁区の大きさよりも大きくする再生層である（以下、再生層とする）。58は再生用光スポットを表わし、59は光磁気ディスク54上の再生すべき所望のトラックである。記録層55と調整層56と再生層57の各層中の矢印は原子スピンの向きを表わし、スピンの向きが相互に逆向きの領域部には磁壁60が形成されている。また、61は再生層

57に転写された磁区の移動しようとしている磁壁を示している。

【0009】図8(c)はこの光磁気ディスク54に形成された温度分布を示すグラフである。磁壁移動再生は1つの光スポットを用いても、2つの光スポットを用いても原理的には可能であるが、ここでは説明の簡便のために、2つの光スポットを用いて再生を行う方法を説明する。図8には再生信号に寄与する光スポットのみを示してある。2つ目の光スポット（不図示）は(c)の温度分布を形成するために照射される。今、位置Xsでは光ディスク54上の温度は調整層56のキュリー温度近傍のTsになっているものとする。(a)の62に示す斜線部はキュリー温度以上になっている部分を示している。

【0010】図8(d)は(c)に示す温度分布に対応する再生層57の磁壁エネルギー密度 σ_1 の分布を示すグラフである。このようにX方向に磁壁エネルギー密度 σ_1 の勾配があると、位置Xに存在する各層の磁壁に対して図中に示す力F1が作用する。このF1は磁壁エネルギーの低い方に磁壁を移動させるように作用する。再生層57は磁壁抗磁力が小さく磁壁移動度が大いので、単独でこの力F1によって容易に磁壁が移動する。しかし、位置Xsより手前（図では右側）の領域では、また光磁気ディスク54の温度がTsより低く、磁壁抗磁力の大きな記録層55との交換結合により、記録層55中の磁壁の位置に対応した位置に再生層57中の磁壁も固定されることになる。

【0011】ここでは、図8(a)に示すように磁壁61が媒体の位置Xsにあるとする。また、位置Xsにおいて光磁気ディスク54の温度は調整層56のキュリー温度近傍のTsまで上昇し、再生層57と記録層55との間の交換結合が切断されるとする。この結果、再生層57中の磁壁61は矢印8で示すようにより温度が高く磁壁エネルギー密度の小さな領域へと瞬間的に移動する。従って、再生用の光スポット58が通過すると、スポット内の再生層57の原子スピンは(b)に示すように全て一方向に揃う。そして、媒体の移動に伴って磁壁61（または60等）が瞬間的に移動し、光スポット内の原子スピンの向きが反転し、全て一方向に揃う。光磁気ディスク54からの反射光は図6従来の光ヘッドで検出し、同様の差動検出を行うことにより、再生信号が得られる。このような磁壁移動再生方式によれば、光スポットによって再生する信号は記録層55に記録されている磁区の大きさによらず常に一定な振幅となり、光学的な回折限界に起因する波形干渉の問題から解放される。つまり、磁壁移動再生を用いれば、レーザ波長 λ と対物レンズのNAから決まる分解能限界の $\lambda/2NA$ 程度よりも小さな磁区の再生を行え、サブミクロンの線密度の再生が可能となる。

【0012】図9は2つの光スポットを用いる場合の光

磁気ヘッドである。光ヘッド5としては図6の1ビームによる光ヘッドと同様なものを用いることができる。7は光ヘッド5の光スポットの位置と磁気ヘッド6の位置を制御する光ヘッド及び磁気ヘッド制御回路である。この制御回路7によりオートトラッキング制御、シーク動作の制御、オートフォーカシング制御を行う。8は情報を記録する際の情報記録回路、9は情報を再生する際の情報再生回路である。

【0021】また、光磁気ディスク4としては、図8等で示したものを採用している。即ち、少なくとも記録層（第1の磁性層）と調整層（第2の磁性層）と再生層（第3の磁性層）の3層の磁性層を含んでいる。その機能についても従来技術の説明と同様である。つまり、記録層は磁区として情報を記録し、調整層は記録層と再生層との間の交換結合力を調整し、再生層は記録層に記録されている磁区を調整層の働きと光スポットによる熱分布とを利用して転写し、更に転写した磁区の磁壁を移動させることにより、記録層に記録されている磁区の大きさよりも大きくするものである。

【0022】磁性層群の各層の具体的な材料としては、遷移金属と希土類金属の各1種類以上の組み合わせによる非晶質合金を用いることができる。例えば、遷移金属としては、主にFe、Co、Ni、希土類金属としては、主にGd、Tb、Dy、Ho、Nd、Smがある。代表的な組み合わせとしてはTbFeCo、GdTbFeCo、GdFeCo、GdTbFeCo、GdDyFeCo等がある。また、耐食性向上のためにCr、Mn、Cu、Ti、Al、Si、Pt、Inなどを少量添加してもよい。更に、これらの層構成にAl、AlTa、AlTi、AlCr、Cuなどの金属層を付加し、熱的な特性を調整してもよい。

【0023】図2は光ヘッド5の構成と光磁気ディスク4の一部を拡大して示す図である。図2を多倍して光磁気ディスク4の隣接するトラック間の媒体特性の連続性を遮断するためのアニール処理を施す方法について説明する。図2において、12は光源としての半導体レーザー、13は半導体レーザー12から射出されたレーザー光を平行光に変換するコリメータレンズである。コリメータレンズ13により変換された平行光は偏光ビームスプリッタ14を経由して対物レンズ15に入射し、対物レンズ15によって光磁気ディスク4の磁性層上に光スポット16が集光される。光磁気ディスク21からの反射光は、再び対物レンズ15を通過して偏光ビームスプリッタ14入射し、ビームスプリッタ14で反射されて17の光束となる。光束17から不図示の光学系により、図6で説明したように光ヘッドのオートトラッキング用、オートフォーカシング用の制御信号の検出や、光磁気再生信号の検出を行う。

【0024】光磁気ディスク4はグループ記録の媒体とし、情報はグループ部に記録するものとする。22a～

22eはランド部、23a～23dはグループ部を示している。光磁気ディスク4は矢印の方向に回転しているものとする。また、18は半導体レーザー12の駆動回路、19は光ヘッドの制御回路、20はディスク4からの反射光を検出する検出回路である。ここで、本実施形態ではこの光磁気ディスク4が初めて情報記録再生装置に挿入されると、再生層での磁壁の移動を可能にするために、隣接トラックの間、即ち、ランド部22の磁性を消失させ、隣接トラック間で媒体特性の連続性を遮断している。これにより、グループ部に記録された磁区は横方向（トラックに平行方向）の磁壁を持たず、情報の意味を持つ磁壁（図8等で説明した磁壁）の移動が可能になる。

【0025】アニール処理を行う際、まず、光ヘッド5を光磁気ディスク4の最外周が、最内周に移動させる。次いで、光ヘッド5からディスク4に光スポットを照射し、その反射光からオートフォーカシング制御信号を検出回路20により検出し、不図示の機構によりフォーカシング制御を行う。次いで、オートトラッキング制御信号を検出回路20で検出し、この際、オートトラッキング制御信号にオフセットを導入、アニールすべきランド部22上を光スポット16が走査するように制御する。光ヘッド5の光スポット16の光強度はランド部の磁性を消失させるだけの高熱のパワーの強度とする。

【0026】例えば、図2のランド部22a上をディスク4の一方の端から他方の端まで制御回路19が半導体レーザー駆動回路18を制御しながら連続的にアニール処理を行う。この場合、半導体レーザー駆動回路18により半導体レーザー12の駆動電流を調整し、光スポットの光強度を調整している。具体的には、ディスク4にプリピット信号として記録する情報、例えばトラック番号、セクタ番号、同期用クロックビットなどの情報に応じて光スポットの光強度を調整し、それらの情報をランド部22aに記録している。図2のランド部22aの斜線で示すアニール幅の変化はこの光スポットの調整によって記録された情報を示している。また、このときの情報は図2のランド部22aの左右のグループを1つのトラックとし、左右のトラックに対する情報を記録する。例えば、トラック番号を記録する場合、ランド部22aに左右のグループの1つのトラック番号を記録する。左右のグループのトラックの判別は後述するように再生時に行う。

【0027】ランド部22aのアニール処理を終了すると、次のランド部22bのアニール処理を行う。この場合も、光スポット16をディスク4のランド部22bに走査し、ランド部22bのアニール処理を行う。但し、この場合は、光スポットの調整は行わず、一定パワーの光スポット16を走査し、図2に斜線で示すようにランド部22bに一定パワーによるアニール処理を行う。次に、図2に示すように光スポット16をランド部22cに移動させてランド部22cのアニール処理を行うが、

ので、記録容量の損失を伴わずにトラック番号等の所定情報を記録でき、記録密度を大幅に高めることができる。特に、磁壁移動再生方式の場合、プリビットによる情報の記録に比べて大幅に記録密度を高めることができる。

【図面の簡単な説明】

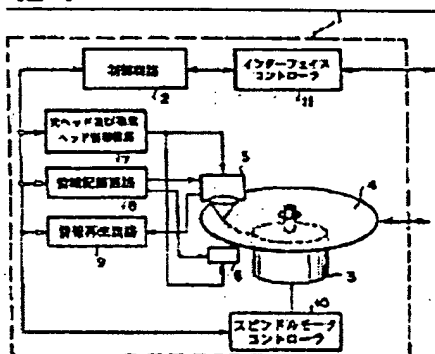
【図 1】 本発明の光学的情報記録再生装置の一実施形態の構成を示す図である。
 【図 2】 グループ記録媒体の場合のアニール方法を説明するための図である。
 【図 3】 ランドグループ記録媒体の場合のアニール方法を説明するための図である。
 【図 4】 グループ記録媒体のアニール処理を施した状態を示す図である。
 【図 5】 ランドグループ記録媒体のアニール処理を施した状態を示す図である。
 【図 6】 従来例の光磁気記録再生装置に用いられるヘッドを示す図である。
 【図 7】 光磁気信号の再生原理を説明するための図である。

【図 8】 磁壁移動再生方式を説明するための図である。
 【図 9】 2ビームによる磁壁移動再生に用いる光ヘッドの例を示す図である。
 【図 10】 図 9 の光ヘッドによる記録媒体上の 2 ビーム及び温度分布を示す図である。

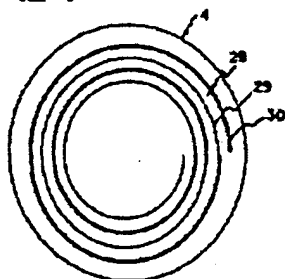
【符号の説明】

- 1 光学的情報記録再生装置
- 2 制御回路
- 4 光磁気ディスク
- 5 光ヘッド
- 6 磁気ヘッド
- 7 光ヘッド及び磁気ヘッド制御回路
- 8 情報記録回路
- 9 情報再生回路
- 12 半導体レーザー
- 13 対物レンズ
- 16 光スポット
- 18 レーザ駆動回路
- 19 光ヘッド制御回路
- 20 検出回路

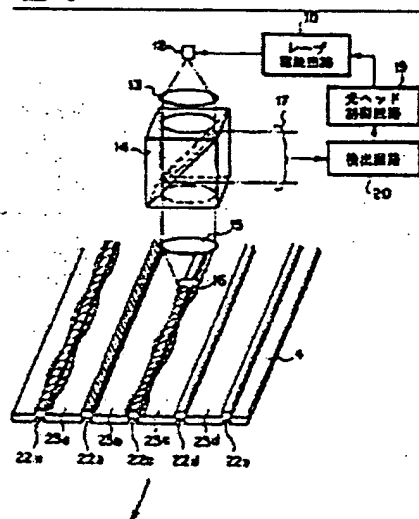
【図 1】



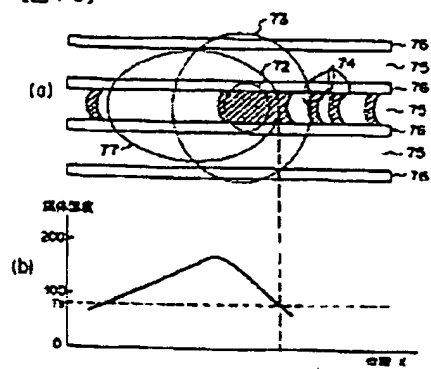
【図 4】



【図 2】



【図10】



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CLAIMS

[Claim(s)]

[Claim 1] As opposed to magneto-optic-recording data medium made as [expand / have a magnetic multilayer which consists of a magnetic layer of at least three layers as a record layer, a magnetic domain wall of a magnetic layer by the side of a playback light exposure moves in the direction of a spot center in the transit direction front of a playback light spot at the time of playback, and / a record magnetic domain] A recording device characterized by having a record means to record a digital signal to above-mentioned magneto-optic-recording data medium, by mark position recording method which is the recording device which records a digital signal, is made to modulate a gap of a record mark and records a signal.

[Claim 2] A recording device according to claim 1 characterized by mark length of the above-mentioned record mark being 2 micrometers or less.

[Claim 3] It has a magnetic multilayer which consists of a magnetic layer of at least three layers as a record layer. In recording a digital signal to magneto-optic-recording data medium made as [expand / in the transit direction front of a playback light spot, a magnetic domain wall of a magnetic layer by the side of a playback light exposure moves in the direction of a spot center, and / at the time of playback, / a record magnetic domain] A record method characterized by recording a digital signal to above-mentioned magneto-optic-recording data medium by mark position recording method which is made to modulate a gap of a record mark and records a signal.

[Claim 4] A record method according to claim 3 characterized by setting mark length of the above-mentioned record mark to 2 micrometers or less.

[Claim 5] It is magneto-optic-recording data medium made as [expand / have a magnetic multilayer which consists of a magnetic layer of at least three layers as a record layer, a magnetic domain wall of a magnetic layer by the side of a playback light exposure moves in the direction of a spot center in the transit direction front of a playback light spot at the time of playback, and / a record magnetic domain]. Magneto-optic-recording data medium characterized by recording a digital signal by mark position recording method which is made to modulate a gap of a record mark and records a signal.

[Claim 6] Magneto-optic-recording data medium according to claim 5 characterized by mark length of the above-mentioned record mark being 2 micrometers or less.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the technology for canceling especially a ghost phenomenon about magneto-optic-recording data medium which expands a record magnetic domain by domain wall displacement, and reproduces a signal, the recording device which records a digital signal on a list to such magneto-optic-recording data medium, and the record method.

[0002]

[Description of the Prior Art] The optical MAG playback system which expands the magnitude of a record magnetic domain effectually and enlarges a regenerative signal is proposed by using the domain wall displacement of the displacement layer in the field in which film temperature turned into more than the Curie temperature of a switch layer in recent years at the time of playback of a signal, using the magnetic multilayer which consists of a magnetic layer, a displacement layer, a switch layer, and a memory layer, of three layers at least as a record layer.

[0003] By this method called DWDD (Domain Wall Displacement Detection), at the time of playback, in the transit direction front of a playback light spot, the magnetic domain wall of the magnetic layer by the side of a playback light exposure (namely, displacement layer) moves in the direction of a spot center, and a record magnetic domain is expanded. therefore, the thing for which a DWDD method is adopted -- the optical limit of playback light -- resolution -- it becomes possible to attain further high recording density-ization, without becoming possible also from the minute record magnetic domain of the following periods to reproduce a very big signal, and changing the wavelength of playback light, the numerical aperture of an objective lens, etc.

[0004]

[Problem(s) to be Solved by the Invention] However, in a DWDD method, there are many troubles which should still be solved and a ghost's problem is in one of them.

[0005] When a signal is reproduced with a DWDD method, after the signal corresponding to the record magnetic domain concerned once disappearing after the signal corresponding to a certain record magnetic domain appears, and going through a certain time amount after that, the behavior that the signal corresponding to the record magnetic domain concerned appears again may be shown. It is the phenomenon in which this is called a ghost, and after going through a certain time amount, the signal which appears again is called a ghost signal. And since such a ghost signal serves as a noise of a regenerative signal, it serves as hindrance when adopting a DWDD method and attaining high recording density-ization.

[0006] This invention is proposed in view of the above conventional actual condition, and aims at providing with magneto-optic-recording data medium the recording device which can cancel the ghost phenomenon in a DWDD method, and the record method list.

[0007]

[Means for Solving the Problem] A recording device concerning this invention is a recording device which records a digital signal to magneto-optic-recording data medium. Here, magneto-optic-recording data medium used as an object for record is magneto-optic-

recording data medium made as [expand / have a magnetic multilayer which consists of a magnetic layer of at least three layers as a record layer, a magnetic domain wall of a magnetic layer by the side of a playback light exposure moves in the direction of a spot center in the transit direction front of a playback light spot at the time of playback, and / a record magnetic domain]. And a recording device concerning this invention is characterized by having a record means to record a digital signal to above-mentioned magneto-optic-recording data medium by mark position recording method which is made to modulate a gap of a record mark and records a signal. In addition, as for mark length of a record mark recorded on magneto-optic-recording data medium, in the above-mentioned recording device, it is desirable that it is 2 micrometers or less.

[0008] A mark position recording method is adopted as record of a digital signal in a recording device concerning above this inventions. Unlike a mark edge recording method which modulates record mark length and records a signal by mark position recording method, record mark length may always be fixed, it may be good, and, moreover, the record mark length concerned may be dramatically short. And a ghost phenomenon in a DWDD method is not produced when a record mark is small enough. Therefore, in a recording device concerning this invention which adopted a mark position recording method as record of a digital signal, a ghost phenomenon in a DWDD method is cancelable.

[0009] Moreover, a record method concerning this invention is related with a record method which records a digital signal to magneto-optic-recording data medium. Here, magneto-optic-recording data medium used as an object for record is magneto-optic-recording data medium made as [expand / have a magnetic multilayer which consists of a magnetic layer of at least three layers as a record layer, a magnetic domain wall of a magnetic layer by the side of a playback light exposure moves in the direction of a spot center in the transit direction front of a playback light spot at the time of playback, and / a record magnetic domain]. And a record method concerning this invention is characterized by recording a digital signal to above-mentioned magneto-optic-recording data medium by mark position recording method which is made to modulate a gap of a record mark and records a signal. In addition, as for mark length of a record mark recorded on magneto-optic-recording data medium, in an above-mentioned record method, it is desirable that it is 2 micrometers or less.

[0010] A mark position recording method is adopted as record of a digital signal by record method concerning above this inventions. Unlike a mark edge recording method which modulates record mark length and records a signal by mark position recording method, record mark length may always be fixed, it may be good, and, moreover, the record mark length concerned may be dramatically short. And a ghost phenomenon in a DWDD method is not produced when a record mark is small enough. Therefore, by record method concerning this invention which adopted a mark position recording method as record of a digital signal, a ghost phenomenon in a DWDD method is cancelable.

[0011] Moreover, magneto-optic-recording data medium concerning this invention is magneto-optic-recording data medium made as [expand / have a magnetic multilayer which consists of a magnetic layer of at least three layers as a record layer, a magnetic domain wall of a magnetic layer by the side of a playback light exposure moves in the direction of a spot center in the transit direction front of a playback light spot at the time of playback, and / a record magnetic domain]. And magneto-optic-recording data medium concerning this invention is characterized by recording a digital signal by mark position recording method which is made to modulate a gap of a record mark and records a signal. In addition, as for mark length of a record mark recorded on above-mentioned magneto-optic-recording data medium, it is desirable that it is 2 micrometers or less.

[0012] A mark position recording method is adopted as record of a digital signal by magneto-optic-recording data medium concerning above this inventions. Unlike a mark edge recording method which modulates record mark length and records a signal by mark position recording method, record mark length may always be fixed, it may be good, and, moreover, the record mark length concerned may be dramatically short. And a ghost phenomenon in a DWDD method is not produced when a record mark is small enough. Therefore, by magneto-optic-

recording data medium concerning this invention which adopted a mark position recording method as record of a digital signal, a ghost phenomenon in a DWDD method is cancelable.

[0013]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to details, referring to a drawing.

[0014] The fundamental configuration of magneto-optic-recording data medium by which this invention is applied is shown in drawing 1. Although this magneto-optic-recording data medium is magneto-optic-recording data medium by which a signal is reproduced with a DWDD method, that fundamental configuration is the same as that of usual magneto-optic-recording data medium. That is, on the transparence substrate 1, laminating formation of a dielectric film 2, the record layer 3, a dielectric film 4, the reflective film 5, and the protective coat 6 is carried out one by one, and this magneto-optic-recording data medium comes, as shown in drawing 1.

[0015] The above-mentioned dielectric films 2 and 4 consist of silicon nitride. However, as for the material of dielectric films 2 and 4, not only this but oxidation silicon, aluminium nitride, etc. may use other dielectric materials. Moreover, the above-mentioned reflective film 5 is for reflecting the light by which incidence was carried out, for example, consists of aluminum. Moreover, the above-mentioned protective coat 6 is for protecting a dielectric film 2, the record layer 3, a dielectric film 4, and the reflective film 5, for example, consists of ultraviolet-rays hardening resin. Although the thickness of these each class can be set as arbitration, it specifically sets [the thickness of a dielectric film 2] thickness of 50nm and the reflective film 5 to 30nm for the thickness of 70nm and a dielectric film 4.

[0016] In addition, although premised on the light for record playback being irradiated from the transparence substrate 1 side here, it is also possible to consider as a configuration with which the light for record playback is irradiated by reverse from a protective coat 6 side. In that case, it differs from the above-mentioned configuration that the lamination of the record layer 3 later mentioned in that the formation location of the reflective film 5 comes between a dielectric film 2 and the transparence substrate 1 and a list becomes reverse.

[0017] And magneto-optic-recording data medium by which this invention is applied is magneto-optic-recording data medium by which a signal is reproduced with a DWDD method, and the record layer 3 consists of three layers, the displacement layer 11, the switch layer 12, and the memory layer 13. That is, as shown in drawing 1, the laminating of the magnetic layer, the displacement layer 11, the switch layer 12, and the memory layer 13, of three layers is carried out, and the record layer 3 is constituted from a playback light incidence side by these. In addition, although explained as that whose record layer 3 is a three-tiered structure, the record layer 3 may be made into the structure of four or more layers here that magneto-optic-recording data medium by which this invention is applied should just be made as [reproduce / by the DWDD method / a signal].

[0018] The following properties are required in order to make it each magnetic layers 11, 12, and 13 which constitute the above-mentioned record layer 3 as [reproduce / with a DWDD method / a signal].

[0019] First, although it is the displacement layer 11, sufficient signal needs to be reproduced also in the temperature at the time of playback, therefore this displacement layer 11 has a high Curie temperature, and needs for a car angle of rotation to be large. Curie-temperature TC1 of the displacement layer 11 at least must be higher than Curie-temperature TC2 of the switch layer 12.

[0020] moreover, it must be made as [move / easily / when switched connection with the switch layer 12 goes out at the time of playback / the displacement layer 11 / a magnetic domain wall], and magnetic domain wall coercive force is small -- if it kicks, it will not become. As for the magnetic domain wall coercive force of the displacement layer 11, specifically, it is desirable that it is 1 or less kOe.

[0021] Moreover, as for the displacement layer 11, consisting of a small material of saturation magnetization is desirable so that migration of a magnetic domain wall may not be barred by the floating magnetic field of itself. Specifically, the saturation magnetization of a

displacement layer is 100 emu/cc. It is desirable that it is the following.

[0022] Moreover, if the thickness of the displacement layer 11 is more than thickness to which a car angle of rotation is sufficient for being saturated, it is enough and, specifically, 20nm – its about 40nm is desirable.

[0023] As a material of the above displacement layers 11, GdFeCo, GdFeCr, etc. are mentioned, for example.

[0024] Next, although it is the switch layer 12, since the role which intercepts the switched connection of the displacement layer 11 and the memory layer 13 at a fixed temperature is borne, this switch layer 12 needs to have predetermined Curie-temperature TC2 which hits that laying temperature.

[0025] Moreover, the thickness of the switch layer 12 is required for homogeneity and the degree which can be intercepted certainly in the switched connection of the displacement layer 11 and the memory layer 13, and, specifically, it is desirable that it is about 5nm or more. However, since there is no merit even if the thickness of the switch layer 12 is too thick not much, it is desirable to be referred to as about 20nm or less.

[0026] As a material of the above switch layers 12, TbFe, TbFeCr, etc. are mentioned, for example.

[0027] Next, although it is the memory layer 13, this memory layer 13 is a layer holding a record magnetic domain, and must hold a minute record magnetic-domain configuration to stability also at the time of playback. Therefore, the Curie-temperature TC3 must be two or more Curie-temperature TCs of the switch layer 12, and it is desired for coercive force and a vertical magnetic anisotropy to be large so that, as for the memory layer 13, a still minuter record magnetic domain can be held to stability.

[0028] Moreover, as for the thickness of the memory layer 13, it is desirable to consider as the thickness which can hold a record magnetic domain to stability, and, specifically, 60nm – its about 100nm is desirable.

[0029] As a material of the above memory layers 13, TbFeCo, TbFeCoCr, etc. are mentioned, for example.

[0030] Below, the actuation at the time of reproducing a signal with a DWDD method from magneto-optic-recording data medium is explained with reference to drawing 2 thru/or drawing 10 which showed each magnetic layers 11 and 12 which constitute the record layer 3, and a concrete example of transition of magnetization of 13. In addition, magneto-optic-recording data medium shall move leftward in drawing by revolution of a disk as data medium here supposing a disk-like thing at the time of record playback.

[0031] In this magneto-optic-recording data medium, as shown in drawing 2, in ordinary temperature and the temperature at the time of playback, it is perpendicularly suitable [each magnetic layer (the displacement layer 11, the switch layer 12, memory layer 13) of three layers which constitutes the record layer 3 is perpendicular magnetic anisotropy films, and / those magnetization] to a film surface at least. And as switched connection acts between the layers of each magnetic layers 11, 12, and 13 which constitute the record layer 3, therefore it is shown in drawing 2 in the usual condition, the direction of the spin of each magnetic layers 11, 12, and 13 has gathered. In addition, in drawing 2 thru/or drawing 10, the arrow head which turned to the vertical direction shows the direction (for example, the magnetization directions which are transition metals, such as Fe or Co) of the spin of each magnetic layer.

[0032] The optical modulation recording system or magnetic field modulation recording method used for the usual magneto-optic recording is used for record over this magneto-optic-recording data medium. And the record over this magneto-optic-recording data medium is mainly made to the memory layer 13, and when the sense of the spin of the memory layer 13 is imprinted by the switch layer 12 and the displacement layer 11, record completes it. Namely, as shown, for example in drawing 2, the record magnetic domains a1, a2, and a3 and ... are recorded on the memory layer 13 by the magneto-optic recording. While those record MAG a1, a2, and a3 and ... are imprinted by the switch layer 12 and the displacement layer 11, consequently magnetic domains b1, b2, and b3 and ... are formed in the switch layer

12 Magnetic domains c1, c2, and c3 and ... are formed in the displacement layer 11.

[0033] And in case a signal is reproduced from this magneto-optic-recording data medium, as shown in drawing 3, the playback light L is irradiated from the side in which the displacement layer 11 is formed. By the exposure of this playback light L, the temperature of magneto-optic-recording data medium rises. That is, as shown in drawing 3, the temperature of data medium of a portion by which the playback light L concerned was irradiated rises by irradiating the playback light L. However, since revolution actuation of the disk is carried out at the time of playback, as for the peak location P of data-medium temperature, the center position S twist of a playback light spot will also be back located a little to the transit direction of the playback light spot concerned.

[0034] It is the switch layer 12 that Curie-temperature TC2 is most set up low among the magnetic layers 11, 12, and 13 of three layers which constitute the record layer 3 by which the playback light L is irradiated here. And by the exposure of the playback light L concerned, the power of the playback light L is set up so that the temperature of the switch layer 12 may exceed Curie-temperature TC2, and so that the temperature of the displacement layer 11 or the memory layer 13 may not exceed those Curie temperature TC1 and TC3. Thus, by setting up the power of the playback light L, by the temperature rise by the exposure of the playback light L, the portion which exceeds Curie-temperature TC2 in the switch layer 12 arises, and magnetization of the portion disappears. In addition, by drawing 3 thru/or drawing 10, temperature exceeds Curie-temperature TC2 of the switch layer 12, a slash is given and the field (a magnetization disappearance field is called hereafter.) where magnetization of the switch layer 12 disappeared is shown.

[0035] The switched connection between the displacement layer 11 and the memory layer 13 stops and working in the field which was able to be warmed to two or more Curie-temperature TCs of the switch layer 12. Here, in the memory layer 13, since it is constituted by a magnetic material with high coercive force with a large magnetic anisotropy, for example, TbFeCo, TbFeCoCr, etc., even if switched connection with other magnetic layers disappears, change does not appear in a record condition. On the other hand, the memory layer 13 has [the displacement layer 11] a magnetic anisotropy and small coercive force conversely, and it is constituted by the material which the magnetic domain wall formed in the perimeter of a record magnetic domain tends to move easily, for example, GdFeCo, GdFeCoCr, etc.

[0036] Therefore, as shown in drawing 3, magnetization of a part of magnetic domains b2 and b3 of the switch layer 12 disappears by the temperature rise by the exposure of the playback light L. If the switched connection between the displacement layers 11 and the memory layers 13 which have the magnetization disappearance field concerned up and down stops working the magnetic domain wall (the example of drawing 3 — the magnetic domain wall mho 1 between the magnetic domain c2 of the displacement layer 11 and a magnetic domain c3) of the displacement layer 11 on the magnetization disappearance field concerned moves in the direction where magnetic energy becomes low. It is in the condition which has the magnetic domain wall mho 1 concerned in the location where temperature is high that magnetic energy becomes low. Therefore, the magnetic domain wall mho 1 concerned will be in the condition that it moves toward the peak location P of data-medium temperature, consequently is shown in drawing 4, as [show / in the arrow head M1 in drawing 3].

[0037] When a magnetic domain wall mho 1 moves toward the peak location P of data-medium temperature in the displacement layer 11, as shown in drawing 4, the magnetic domain c3 of the displacement layer 11 will be expanded. That is, in the transit direction front of a playback light spot, the magnetic domain wall mho 1 of the displacement layer 11 moves in the direction of a spot center, and the magnetic domain c3 of the displacement layer 11 corresponding to the record magnetic domain a3 of the memory layer 13 is expanded. Consequently, since the magnetic domain c3 of the displacement layer 11 which contributes to playback is expanded even if the record magnetic domain a3 of the memory layer 13 is minute, a big regenerative signal comes to be acquired.

[0038] Then, if between [all] the record magnetic domain a3 of the memory layer 13 and the magnetic domains c3 of the displacement layer 11 become a magnetization disappearance

field with a revolution of a disk as shown in drawing 5, the switched connection between the record magnetic domain a3 of the memory layer 13 and the magnetic domain c3 of the displacement layer 11 will go out. Then, the magnetic domain wall mho 2 between the magnetic domain c3 of the displacement layer 11 and a magnetic domain c4 moves in the direction where magnetic energy becomes low. It is in the condition which has the magnetic domain wall mho 2 concerned in the location where temperature is high that magnetic energy becomes low. Therefore, the magnetic domain wall mho 2 concerned will be in the condition that it moves toward the peak location P of data-medium temperature, consequently is shown in drawing 6, as [show / in the arrow head M2 in drawing 5].

[0039] When a magnetic domain wall mho 2 moves toward the peak location P of data-medium temperature in the displacement layer 11, as shown in drawing 6, the magnetic domain c4 of the displacement layer 11 will be expanded. That is, in the transit direction front of a playback light spot, the magnetic domain wall mho 2 of the displacement layer 11 moves in the direction of a spot center, and the magnetic domain c4 of the displacement layer 11 corresponding to the record magnetic domain a4 of the memory layer 13 is expanded. Consequently, since the magnetic domain c4 of the displacement layer 11 which contributes to playback is expanded even if the record magnetic domain a4 of the memory layer 13 is minute, a big regenerative signal comes to be acquired.

[0040] Then, if between [all] the record magnetic domain a4 of the memory layer 13 and the magnetic domains c4 of the displacement layer 11 become a magnetization disappearance field with a revolution of a disk as shown in drawing 7, the switched connection between the record magnetic domain a4 of the memory layer 13 and the magnetic domain c4 of the displacement layer 11 will go out. Then, the magnetic domain wall mho 3 between the magnetic domain c4 of the displacement layer 11 and a magnetic domain c5 moves in the direction where magnetic energy becomes low. It is in the condition which has the magnetic domain wall mho 3 concerned in the location where temperature is high that magnetic energy becomes low. Therefore, the magnetic domain wall mho 3 concerned will be in the condition that it moves toward the peak location P of data-medium temperature, consequently is shown in drawing 7, as [show / in the arrow head M3 in drawing 7].

[0041] When a magnetic domain wall mho 3 moves toward the peak location P of data-medium temperature in the displacement layer 11, as shown in drawing 7, the magnetic domain c5 of the displacement layer 11 will be expanded. That is, in the transit direction front of a playback light spot, the magnetic domain wall mho 3 of the displacement layer 11 moves in the direction of a spot center, and the magnetic domain c5 of the displacement layer 11 corresponding to the record magnetic domain a5 of the memory layer 13 is expanded. Consequently, since the magnetic domain c5 of the displacement layer 11 which contributes to playback is expanded even if the record magnetic domain a5 of the memory layer 13 is minute, a big regenerative signal comes to be acquired.

[0042] As mentioned above, even if the record magnetic domain which the magnitude of a record magnetic domain is expanded effectually and formed in the memory layer 13 by this magneto-optic-recording data medium of the domain wall displacement of the displacement layer 11 in the field in which film temperature became two or more Curie-temperature TCs of the switch layer 12 is minute, it is possible to acquire a big regenerative signal. That is, it is possible to reproduce a signal also from the detailed record magnetic domain which cannot be reproduced in the usual optical system by a series of domain-wall-displacement actuation as shown in drawing 8 from drawing 3.

[0043] By the way, if the left end of the record magnetic domain a3 of the memory layer 13 passes through the left end location of the magnetization disappearance field of the switch layer 12 as a disk rotates further and it is shown in drawing 9 after that, temperature will fall and magnetization of the switch layer 12 will be recovered. Then, the spin of the same direction as the record magnetic domain a3 of the memory layer 13 arises in the switch layer 12, and the spin of the same direction also as the displacement layer 11 arises by the switched connection of the switch layer 12 and the displacement layer 11 further. Consequently, the magnetic domain c3 corresponding to the record magnetic domain a3 of

the memory layer 13 is again formed in the displacement layer 11, and new magnetic domain wall mhoa arises in the displacement layer 11.

[0044] Then, magnetic energy also moves magnetic domain wall mhoa produced here to the location used as min. It is in the condition which has the magnetic domain wall mhoa concerned in the location where temperature is high that magnetic energy becomes low. Therefore, migration of magnetic domain wall mhoa at this time will be migration in the direction of a spot center, and if it puts in another way, it will be migration in the direction to which the magnetic domain c3 of the displacement layer 11 is made to expand. Namely, the magnetic domain wall mhoa concerned will be in the condition that it moves toward the peak location P. of data-medium temperature, consequently is shown in drawing 10, as [show / in the arrow head M4 in drawing 9].

[0045] When magnetic domain wall mhoa moves toward the peak location P of data-medium temperature in the displacement layer 11, as shown in drawing 10, the magnetic domain c3 of the displacement layer 11 will be expanded again. That is, in the transit direction back of a playback light spot, magnetic domain wall mhoa of the displacement layer 11 moves in the direction of a spot center, and the magnetic domain c3 of the displacement layer 11 corresponding to the record magnetic domain a3 of the memory layer 13 is expanded again. Consequently, as for close, the magnetic domain c3 of the displacement layer 11 corresponding to the record magnetic domain a3 of the memory layer 13 which playback has already completed will come in a playback light spot again. Therefore, the signal corresponding to the magnetic domain c3 by which close came for the regenerative signal in the playback light spot again will also appear. This is a ghost signal.

[0046] Thus, since amplification actuation of the record magnetic domain concerned arises also in the back field of a playback light spot at the time of the signal regeneration by the DWDD method once a record magnetic domain passes a playback light spot, the signal already once reproduced in the front field of a playback light spot will be reproduced again. That is, by the DWDD method, two signals with which time amount shifted are detected to one record magnetic domain. Among these, since not being reproduced originally is desirable as for the 2nd signal, it is called a ghost signal.

[0047] Here, paying attention to one record magnetic domain, an example of the result of having measured time amount change of the signal acquired from the record magnetic domain concerned is shown in drawing 11. As shown in drawing 11, when a signal is reproduced by the DWDD method, two signals S1 and S2 with which time amount shifted are detected to one record magnetic domain. Here, it is a signal acquired when a magnetic domain is expanded in the front location of the playback light spot transit direction, and properly speaking [the big signal S1 which appears first], it is desirable [the signal] to reproduce only this signal S1. However, the small signal S2 is detected after that. This signal S2 is a signal acquired when a magnetic domain is expanded in the back location of the playback light spot transit direction, and this is a ghost signal.

[0048] Since the ghost signal produced when a DWDD method is adopted as mentioned above and a signal is reproduced serves as a noise of a regenerative signal, it serves as hindrance when adopting a DWDD method and attaining high recording density-ization. However, a ghost phenomenon is not produced when the period of the record magnetic domain currently formed in the memory layer 13 is short enough, since the field which is carrying out switched connection to the displacement layer 11 must be more than a certain amount of length in order for a magnetic domain wall to move in the displacement layer 11. This is explained with reference to drawing 9.

[0049] If the left end of the record magnetic domain a3 of the memory layer 13 passes through the left end location of the magnetization disappearance field of the switch layer 12 as shown in drawing 9, the magnetic domain c3 corresponding to the record magnetic domain a3 of the memory layer 13 will be formed in the displacement layer 11. However, formation of the magnetic domain c3 corresponding to the record magnetic domain a3 of the memory layer 13 is not immediately made, when the left end of the record magnetic domain a3 of the memory layer 13 passes through the left end location of a magnetization disappearance field.

That is, the left end of the record magnetic domain a3 of the memory layer 13 passes a magnetization disappearance field, in the phase in which the field which magnetization of the switch layer 12 recovered on the record magnetic domain a3 of the memory layer 13 became large enough, a magnetic domain c3 is formed in the displacement layer 11, and migration of magnetic domain wall mhoa of the magnetic domain c3 concerned starts.

[0050] Thus, the left end of the record magnetic domain a3 of the memory layer 11 passes through the left end location of a magnetization disappearance field, and produces migration of magnetic domain wall mhoa in the back location of the playback light spot transit direction after a while. Therefore, when the period of the record magnetic domain currently formed in the memory layer 13 is short enough, the magnetic domain c3 of close coming in a playback light spot again of the displacement layer 11 corresponding to the record magnetic domain a3 of the memory layer 13 which playback has already completed (namely, when a record mark is small enough) is lost in the back location of a playback light spot.

[0051] As mentioned above, if a record mark is made small enough and the period of a record magnetic domain is shortened enough, in order to verify that a ghost signal stops appearing, the signal was actually reproduced about the case where record mark length is set to 0.3 micrometers, the case where record mark length is set to 0.2 micrometers, and the case where record mark length is set to 0.1 micrometers. And although the ghost signal was detected when it investigated whether a ghost signal would be detected, and record mark length was 0.3 micrometers, as for the ghost signal, record mark length was not detected at the time of 0.2 micrometers or 0.1 micrometers. When making the record mark small enough and shortening the period of a record magnetic domain enough from this, a ghost signal ceased to appear and it specifically turned out that about 0.2 micrometers or less, then the effect of a ghost signal are [record mark length] avoidable.

[0052] As mentioned above, a ghost phenomenon is not produced when the period of the record magnetic domain currently formed in the memory layer 13 is short enough. So, in recording a signal on magneto-optic-recording data medium, in this invention, a digital signal is recorded by the mark position recording method which is made to modulate the gap of a record mark and records a signal.

[0053] When recording a digital signal on high density to magneto-optic-recording data medium conventionally, the mark edge recording method which modulates record mark length and records a signal was adopted. When not adopting a DWDD method since it can advance high density record-ization even if a record mark long in comparison is used for a mark edge recording method, and attaining high recording density-ization, it was effective.

[0054] However, by the mark edge recording method, since record mark length is modulated, two or more record marks from which length differs from a short record mark to a long record mark will be used. Therefore, when it was going to reproduce the signal recorded by the mark edge recording method by the DWDD method, a ghost signal which the long record mark mentioned above by the way tended to appear. Therefore, in having recorded by the mark edge recording method, even if it adopted the DWDD method as playback of a signal, it was difficult to advance high recording density-ization.

[0055] On the other hand, the mark position recording method is adopted in this invention. Since information will be given to the gap of a record mark and a record mark by the mark position recording method, the record mark to be used is good by the record mark fixed [mark length] and short. Then, if the record mark length is made short enough to the degree in which a ghost signal does not appear, even if it adopts a DWDD method, it will be lost that a ghost signal appears and a good regenerative signal will come to be acquired. Therefore, in a DWDD method, by adopting a mark position recording method, the effect of a ghost signal is avoided and it becomes possible to advance high recording density-ization.

[0056] In addition, if record mark length is 0.2 micrometers or less as the result of the experiment mentioned above also shows, a ghost signal will cease to appear. Therefore, in adopting a mark position recording method, it is desirable to set the record mark length to 0.2 micrometers or less.

[0057] By the way, in a mark position recording method, in order to attain further high

recording density-ization, to shorten record mark length more is desired. And it is modification in the direction where a ghost signal stops appearing to shorten record mark length. Therefore, it is dramatically effective to adopt a mark position recording method in a DWDD method also from this point, when advancing further high recording density-ization.

[0058] Below, a concrete example is given and explained about the record playback by the mark position recording method. In addition, although the example which used the RLL (1 7) modulation technique is given, in this invention, especially the modulation technique of a digital signal is not limited and can adopt the modulation technique of arbitration here.

[0059] First, a record process is explained, referring to drawing 12 and drawing 13. In addition, if mark position record is performed, what kind of method will be sufficient as the signal-processing method in a record process, and it will not be limited to a method which is explained below.

[0060] At the time of record, first, with an encoder 21, the input data bit train which consists of "0" and "1" is modulated to the modulation (1 7) data A1 of NRZ (Non Return to Zero), as shown in drawing 12 (a). Next, with the amplifier 22 for record, the modulation data A1 concerned is changed into square wave-like record current A2, as shown in drawing 12 (b), and the record current A2 concerned is supplied to an optical pickup 23. And an optical pickup 23 impresses a magnetic field to magneto-optic-recording data medium while it carries out outgoing radiation of the laser beam from a laser diode LD and irradiates the laser beam concerned at magneto-optic-recording data medium based on record current A2, and as shown in drawing 12 (c), it records a record mark by the magneto-optic recording to magneto-optic-recording data medium.

[0061] At this time, it records that each record mark corresponds to "1" of modulation data, respectively on magneto-optic-recording data medium. By this, much record marks of short fixed mark length will be recorded on magneto-optic-recording data medium, and the gap of an adjacent record mark will show information to it. In addition, in recording a record mark on magneto-optic-recording data medium by the mark position recording method in this way, as mentioned above, it is desirable [the mark length of those record marks] to be referred to as 0.2 micrometers or less. In addition, the magnetic field modulation technique which sends and records record current A2 on the magnetic head is sufficient as the recording method at this time.

[0062] Below, a renewal process is explained, referring to drawing 12 and drawing 14. In addition, if it seems that the signal-processing method in a renewal process detects the center position of the record mark recorded by the mark position recording method, what kind of method will be sufficient as it, and it will not be limited to a method which is explained below.

[0063] At the time of playback, a DWDD method which was mentioned above by the optical pickup 23 detects the record mark currently first recorded on magneto-optic-recording data medium as shown in drawing 12 (c). At this time, an optical pickup 23 detects the reflected light from magneto-optic-recording data medium using Photodiode PD. And the output from Photodiode PD is changed into a voltage signal while it is amplified by the amplifier 24 for playback, and it is outputted as a wave-like regenerative signal B1 as shown in drawing 12 (d). Here, the good regenerative signal B1 is acquired, without being influenced of a ghost, even if it adopts a DWDD method and reproduces since the record mark currently recorded on magneto-optic-recording data medium is a record mark of short and fixed mark length.

[0064] And a high frequency component decreases the regenerative signal B1 outputted from the amplifier 24 for playback with a low pass filter 25, and after considering as wave-like signal B-2 as shown in drawing 12 (e), it is supplied to a differentiator 26 and the 1st discriminator 27, respectively. Here, a differentiator 26 asks for the differential component of signal B-2 which has passed the low pass filter 25, generates the differential signal B3 as shown in drawing 12 (f), and supplies the differential signal B3 concerned to the 2nd discriminator 28.

[0065] And the 1st discriminator 27 generates binary-ized signal B4 as shown in drawing 12 (g) from signal B-2 which has passed the low pass filter 25, and the 2nd discriminator 28

generates binary-ized signal B5 as shown in drawing 12 (h) from the differential signal B3 supplied from the differentiator 26. In addition, let mostly discrimination level of the discriminators 27 and 28 at this time be an amplitude center.

[0066] Next, binary-ized signal B4 generated by the comparator 29 by the 1st discriminator 27 is compared with binary-ized signal B5 generated by the 2nd discriminator 28, and regenerative-signal pulse B6 as shows those duplication signal components to ejection and drawing 12 (i) is generated.

[0067] Regenerative-signal pulse B6 corresponding to the data recorded as mentioned above is obtained. However, this regenerative-signal pulse B6 is not used as playback data as it is, but further, a playback clock is extracted, a synchronization is taken with the playback clock concerned using this regenerative-signal pulse B6, by PLL (Phase Locked Loop)33 which consists of a phase comparator 30, a low pass filter 31, and a voltage controlled oscillator 32, and the synchronous processing circuit 34 generates the playback data B7 as shown in drawing 12 (j). And the data bit train of a basis is reproduced by decoding this playback data B7 with a decoder 35.

[0068] As mentioned above, a good regenerative signal is acquired, without being influenced of a ghost, even if it reproduces a signal by the DWDD method since the record mark recorded on magneto-optic-recording data medium turns into only a record mark of short and fixed mark length when a mark edge recording method performs record playback. Therefore, the effect of a ghost signal is avoided and it becomes possible to attain further high recording density-ization because it is made to perform record playback by the mark edge recording method.

[0069]

[Effect of the Invention] As explained to details above, according to this invention, the ghost phenomenon in a DWDD method can be canceled and it becomes possible to attain further high recording density-ization of magneto-optic-recording data medium.

[Translation done.]